Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

AD-A150 856

(2)

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) AFGL-TR-85-0010	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Air Force Geophysics Laboratory 6b. OFFICE SYMBOL (If applicable) OPA	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State and ZIP Code) Hanscom AFB Massachusetts 01731	7b. ADDRESS (City, State and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State and ZIP Code)	10. SOURCE OF FUNDING NOS. PROGRAM ELEMENT NO. 62101F; PROJECT NO. 7670; TASK NO. 16; WORK UNIT NO. 03
11. TITLE (Include Security Classification) Air Force Geophysics Laboratory's (AFGL) Mobile CO2 Doppler Lidar	
12. PERSONAL AUTHOR(S) S. B. Alejandro; D. R. Fitzgerald	
13a. TYPE OF REPORT REPRINT 13b. TIME COVERED FROM ______ TO ______	14. DATE OF REPORT (Yr., Mo., Day) 1985 January 28 15. PAGE COUNT 4
16. SUPPLEMENTARY NOTATION Presented at the Conference on "Optical Remote Sensing of the Atmosphere", 15-18 Jan 1985 at Incline Village, Nevada	
17. COSATI CODES FIELD / GROUP / SUB. GR.	18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) CO2 laser, Doppler lidar, Remote measurement of wind fields, Aerosol backscatter measurement, and Real-time analysis of lidar data.

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

A mobile, pulsed, coherent, Doppler CO2 lidar is being developed at Air Force Geophysics Laboratory. The system will be used to develop real-time techniques for determining wind field structures and evaluating aerosol backscatter measurements over path lengths of 1 km to 20 km range. Originator supplied keywords include:

DTIC FILE COPY

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS ☐	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL Steven B. Alejandro	22b. TELEPHONE NUMBER (Include Area Code) (617) 861-4774 22c. OFFICE SYMBOL AFGL/OPA

DD FORM 1473, 83 APR — EDITION OF 1 JAN 73 IS OBSOLETE.

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SECURITY CLASSIFICATION OF THIS PAGE

85 02 15 044

AFGL-TR-85-0010

Air Force Geophysics Laboratory's (AFGL) Mobile CO2 Doppler Lidar

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INTRODUCTION

AFGL is developing a mobile coherent, pulsed, Doppler CO_2 lidar system designed to evaluate techniques for the acquisition and real-time interpretation of atmospheric wind field structure as well as aerosol attenuation and concentrations over long path lengths. The system utilizes a low chirp electron beam injection CO_2 TEA laser which is mode locked by hole injection from a Littrow grating tuned low pressure flowing gas cw CO_2 laser. An identical low pressure laser is used as the local oscillator. The entire optical assembly is mounted upon a 2.7m x 1.3m optical table, with the exception of the scanner which is mounted over the table on an elevator system. The scanner system is raised through a hatch in the trailer roof and is capable of full hemispherical and fixed point scanning. The return signal is detected in the usual superheterodyne technique by a Hg:Cd:Te detector. The system IF amplifier output will be split to allow simultaneous real time analog display of velocity as a function of range and digital conversion for obtaining power, velocity, and variance characteristics of the signal. A schematic of the system is shown in figure 1 and the system design parameters are given in Table 1. The entire lidar system along with field operations support equipment will be housed in a modified 12m semi trailer.

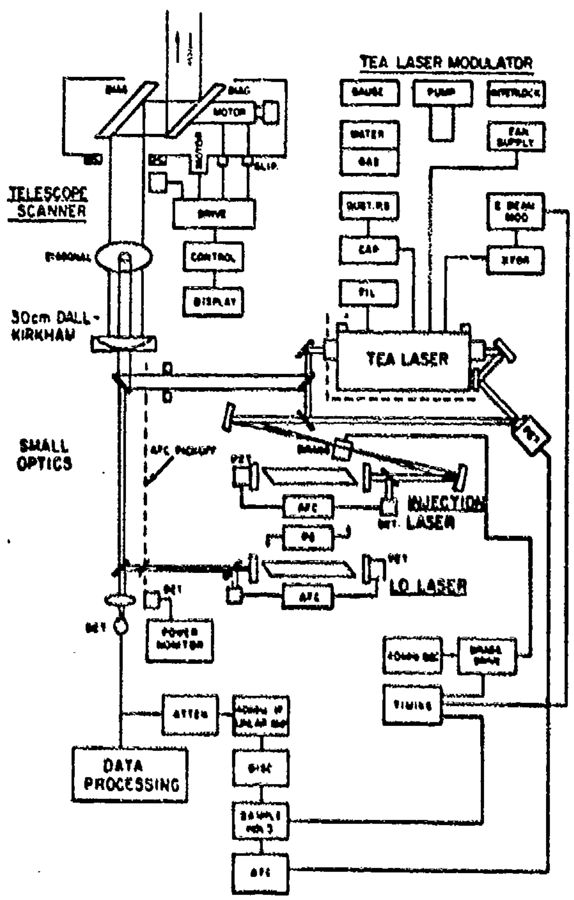

Figure 1. AFGL Mobile Doppler Lidar System

TABLE I

SYSTEM DESIGN PARAMETERS

WAVELENGTH	TUNABLE IN 9 & 10µm BANDS, NORMALLY 10.59 µm
PULSE ENERGY	.2 - 1.0 JOULES
PULSE LENGTH	1.0 - 5.0 µs
FREQ. CHIRP	≤ .2 MHz P - P
PRF	1.0 - 50.0 PPS
RANGE	1.0 - 32 km
TELESCOPE	30 cm DALL - KIRKHAM
DETECTOR	HgCdTe, 6 HOUR DEWAR
ROOF SCANNER	ELEVATION : 0° TO 90°, .25 ACCURACY AZIMUTH 0° TO 360°, .25 ACCURACY
DIGITAL PROCESSING	FFT, PULSE PAIR

LIDAR OPTICAL SYSTEM

The basic optical system and TEA laser were designed by G.B. Jacobs at General Electric Electronics Laboratory. The laser is capable of generating long coherent pulses or pulse bursts. The unit uses a tungsten filament electron gun, which generates 120 kV, 15 A pulses of either 10 µs or 5 µs duration at up to 50 Hz repetition to preionize the laser plasma. The laser plasma is then excited by a 20 kV, 100 A pulse supplied by the sustainer supply. The resultant laser output pulses will be of either 5 µs or 1 µs duration. A Littrow grating tuned low pressure flowing gas cw CO2 laser that is frequency dither stabilized is used as the TEA laser injection source. The injection laser frequency is shifted 40 MHz before injection into the unstable TEA laser cavity by a Bragg modulator to provide the necessary frequency offset for bipolar Doppler signal estimation. The TEA laser output is annular and of single wavelength and transverse mode.

The output from the TEA laser is then directed upon the spherical convex secondary of the Dall-Kirkham telescope and undergoes a 4X magnification to 16cm in diameter. The beam then is reflected by a 30.5cm x 43.2cm diagonal mirror vertically up to the scanner which has been raised through the trailer roof. A schematic of the TEA laser and transmitter optics is given in figure 2.

The backscattered return signal is received in a coaxial ring about the transmitted energy pattern and is focused by a spherical mirror upon the Hg:Cd:Te detector. A low pressure laser similar to the injection laser is used as the local oscillator (LO). The LO laser is tuned by a Littrow grating with the frequency dither stabilized. The output of the LO is attenuated to approximately 1mW and is then focused onto the detector. Figure 3 shows the receiver optical elements and beam paths.

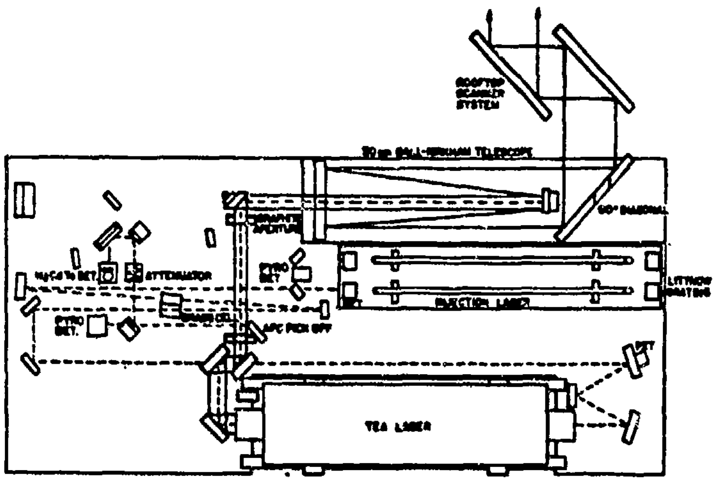

Figure 2. TEA laser and transmitting optics.

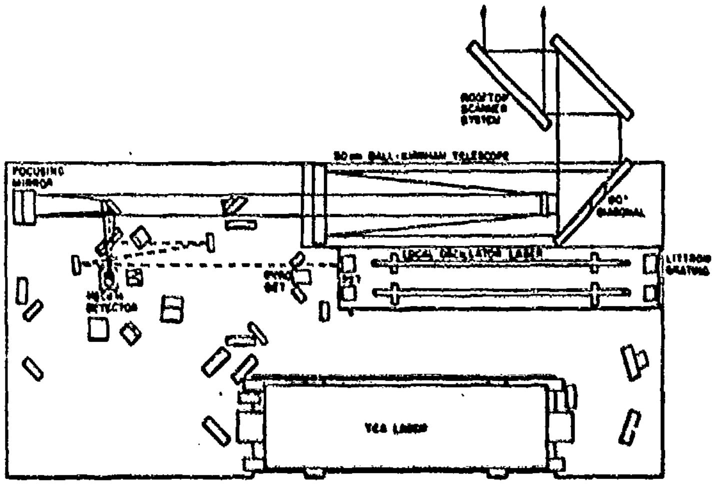

Figure 3. Receiving Optics.

DATA PROCESSING

The backscattered return signals will contain information on the specular (glint) or diffuse (speckle) nature of targets over an expected range of 32km. The received backscatter is combined with local oscillator energy on the LN cooled detector. The resultant low level beat frequency Doppler velocity information is contained in a wide band noise signal. At 10.59 μm, the Doppler shift is 188.5 kHz per meter/sec radial drift velocity. The system design is for ± 50 m/s radial velocity, thus requiring a 20 MHz IF bandwidth for direct analysis or display of the data. The IR detector output is amplified and split into two paths. The first is used to maintain frequency control of the lasers through PZT path length corrections on the optical bench. The data pass band is center frequency shifted from 40 MHz to 70 MHz and passed through a wideband log IF amplifier.

The amplifier outputs are used in several ways. One output goes directly to an FM discriminator for real time analog display of velocity as a function of range, and for optional voltage control oscillator (VCO) control of the data channel center frequency. This will be used in the frequency tracking pulse-matched filter mode for maximum range detection tests. This signal path is depicted by the dashed lines in figure 4. Other data from the wideband log amplifier are passed through a complex multiplier to synthesize real and quadrature shifted signals for high speed conversion within the pulse to the digital data needed for covariance, pulse pair, or FFT algorithm processing for recovering the power, velocity, and variance characteristics of the signal as a function of range, azimuth, and elevation. The video from this amplifier is available for envelope detection and spectrum analysis tests.

It is intended to adapt several of the existing Doppler weather radar software packages used for data analysis and composite parameter displays to this lidar's computer and graphics display system so that PPI or RHI patterns of the wind field and contoured maps of the aerosol concentration can be determined and displayed shortly after the necessary sequences of backscatter scan data have been acquired.

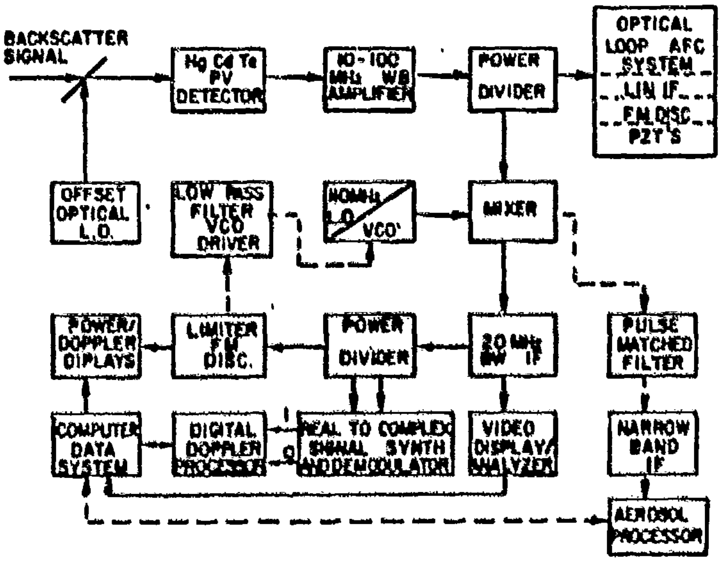

Figure 4. Data Processing System.

CONCLUSION

The lasers and optical systems are currently being tested in the laboratory. Once the testing has been completed the system will be installed in the trailer and moved to the Air Force laser range at the Ft Devens Annex, Sudbury, Massachusetts for operational testing.